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LYCOMING

DIVISION - THE AVIATION CORPORATION

WILLIAMSPORT, PENNA.

2 - DESIGN CALCULATION FOR INITIAL
REED VALVE COMBUSTION CHAMBER
DRAWING NO. 70727
3 - ITEM III, CONTRACT NOa(s)-4718

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DIVISION--THE AVIATION CORPORATION

REPORT NO. 936

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ABSTRACTED

[redacted]

DESIGN CALCULATION FOR INITIAL REED VALVE COMBUSTION CHAMBER DRAWING NO. 70727 ITEM III, CONTRACT NOa(s)-4718

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DESIGN CALCULATION FOR INITIAL REED VALVE COMBUSTION CHAMBER

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DESIGN CALCULATION FOR INITIAL REED VALVE COMBUSTION CHAMBER

OBJECT:

1. The object of this report is to examine the properties of the reed valves shown in the layout of a combustion chamber, Dwg. No. 70727.

RESULTS:

2. The calculated pressure drop thru the valves is .37 psi.

3. The natural frequency of the valve reeds is 146 cycles/sec.

4. The maximum stress in the valve reeds due to bending is 43,500 psi.

CONCLUSION:

5. The proportions of the valves shown on layout 70727 are rational and can be recommended for the initial testing of an automatic valve combustion chamber.

DESCRIPTION:

6. Lycoming Division, The Aviation Corporation Engineering Report No. 854, entitled, Preliminary Design Calculations for Intermittent Combustion Chambers, gives the rough calculations for an intermittent combustion chamber with particular reference to a mechanically operated rotary valve. Such a chamber is currently under construction.

7. An alternative scheme using automatic valves of the feather or reed description is mentioned in paragraph 6 of the above report and has been incorporated in a tentative design as shown by layout #70727, page 6 . Eighteen reed valves disposed cylindically about the combustion chamber is the principal feature of this design.

8. A single reed valve similar to those shown in the above layout has been made and tested for airflow capacity as reported in Lycoming Engineering Report No. 928.

9. The purpose of this report is to evaluate the design of layout #70727 in the light of reports No's 854 and 928.

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PRESSURE DROP IN VALVE:

10. From paragraph 28 of report No. 854 air is to enter the valve at a pressure of 73.5 psi and at the rate of 1.32 lb. per sec. average and a specific volume of 4.5 ft. 3/lb. The flow takes place during .54 of the cycle. The actual weight flow rate is therefore

$$1.32/.54 = 2.48 \text{ lb. per sec.}$$

$$\text{or } \frac{2.48 \times 60}{18} = 8.26 \text{ lb/min/reed.}$$

11. The valve deflection is probably nearly directly proportional to the mass flow of air and it is apparent from curve No. 6191 page 5 that 8.26 lb/min. is insufficient to fully open the reed. At this point the pressure drop across the valve is seen to be 4.8 in Hg at a discharge pressure of 29.47 in Hg or an inlet pressure of 16.8 psi at a temperature of 80°F., resulting in a specific volume for this point of the flow test of

$$V = \frac{RT}{P} = \frac{53.35 \times 540}{144 \times 16.8} = 11.9 \text{ ft } 3/\text{lb}$$

12. Ignoring compressability effects the pressure drops thru a single reed valve at equal mass flows should be approximately proportional to the specific volume of the fluid. The pressure drop thru the multiple valve at design condition should then be

$$P = 4.8 \frac{4.5}{11.9} = 1.8 \text{ in hg.}$$

or .37 psi

13. This very moderate pressure drop is principally the result of the very large curtain area of the valves. The total area is 36 $in.^2$ at full opening and therefore the area at the design condition by reference to curve No. 6191 and assuming that the opening is proportional to mass flow -

$$A = 36 \frac{8.26}{14} = 21.5 \text{ inch}^2$$

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NATURAL FREQUENCY OF REED:

14. The natural frequency of the reed in question is readily calculated as a simply supported rectangular beam of uniform cross section for which it can be shown that in the first mode

$$f = \frac{\pi h}{2 l^2} \sqrt{\frac{E g}{12 w}}$$

where f = frequency - cycles per sec.

h = thickness of beam - inches

l = length of beam - inches

E = Young's modulus

g = acceleration of gravity in/sec^2

w = density, lb/in^3

$$\text{hence } f = \frac{\pi .031}{2 \times 4.4^2} \sqrt{\frac{30 \times 10^6 \times 386}{12 \times 0.281}}$$

= 146 cycles per second

This natural frequency of vibration is a measure of the valve's ability to close promptly upon cessation of flow. The closing period is one quarter of the vibration period or $\frac{1}{4 \times 146}$ = .0017 seconds. This is the time required by the valve to move from a stationary open position to a fully closed position. At an explosion frequency of 25 cycles per second this closing requires .04 of the total time of the cycle.

STRESS IN REED:

15. It can be shown that a simply supported uniformly loaded rectangular beam has a maximum apparent stress of

$$S = 4.8 \frac{}{l^2}$$

Where

s = maximum stress, psi

E = Young's modulus

h = thickness, inches

f = maximum deflection, inches

l = length, inches

which is for the assembly described in report No. 928.

$$s = \frac{4.8 \times 30 \times 10^6 \times .031 \times .189}{4.4^2} = 43,500 \text{ psi}$$

REFERENCES:

a. Lycoming Division, The Aviation Corporation Report No. 854, Preliminary Design Calculations for Intermittent Combustion Chambers.

b. Lycoming Division -The Aviation Corp. Report No. 928, Air Flow Investigation of Reed Valve.

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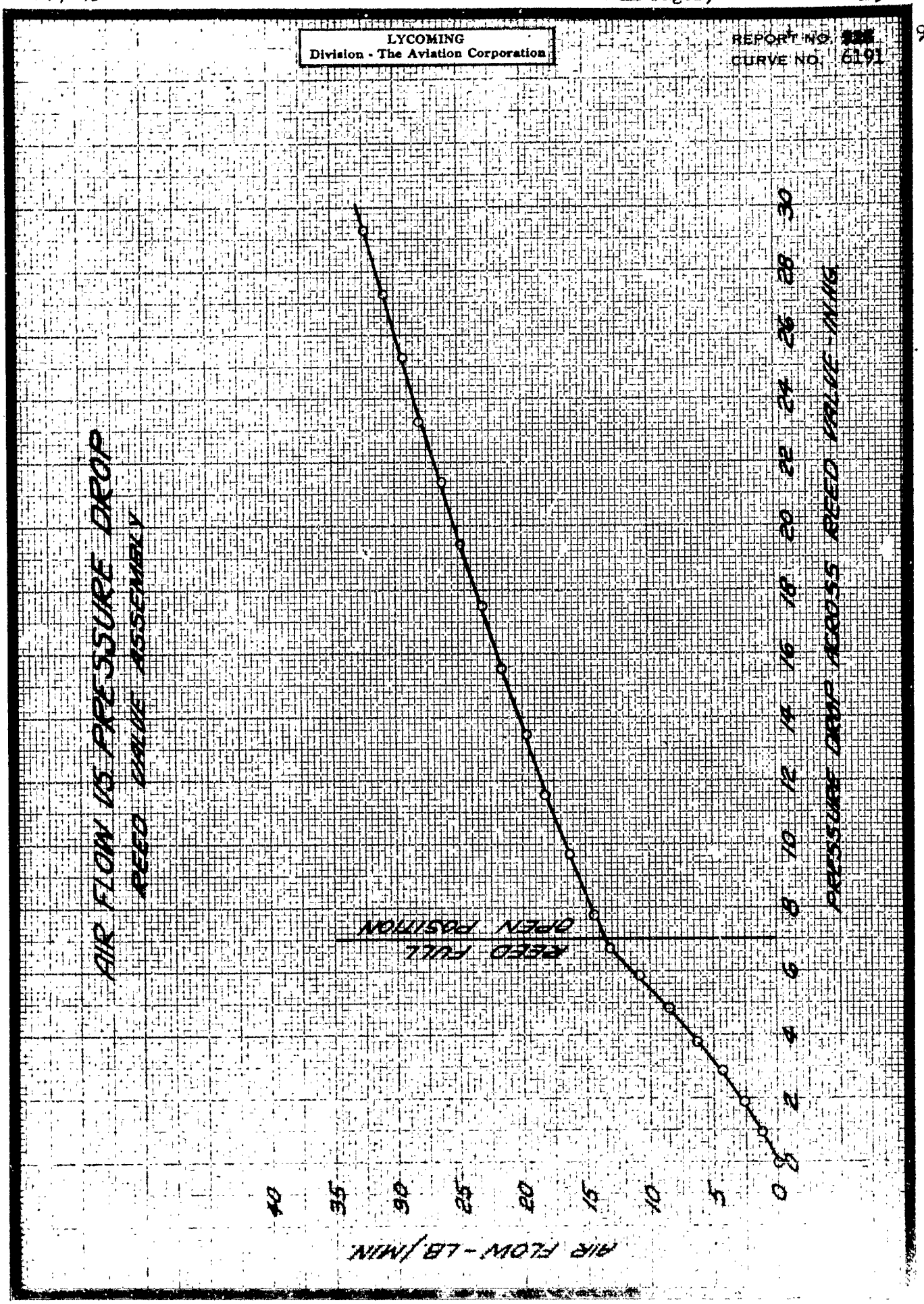
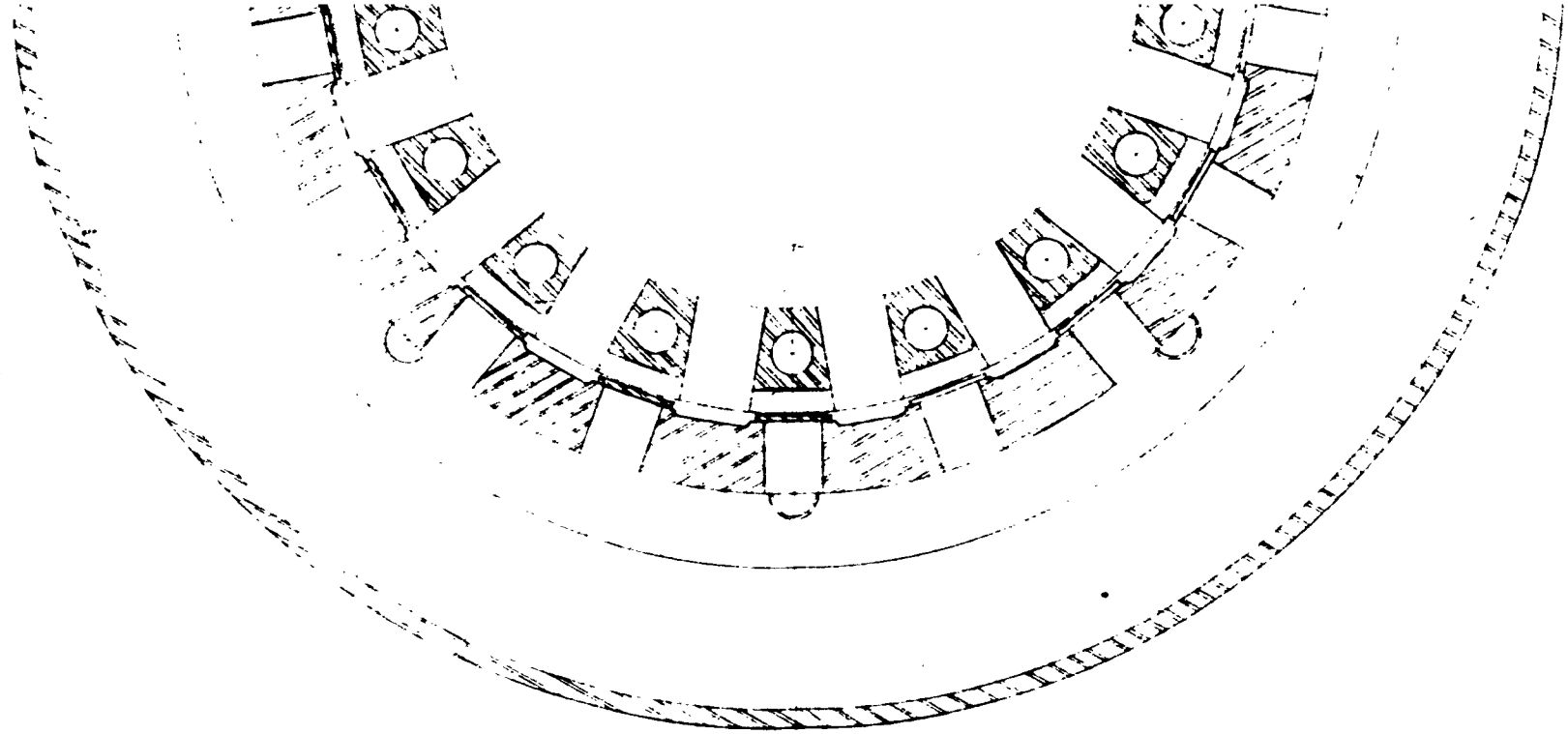
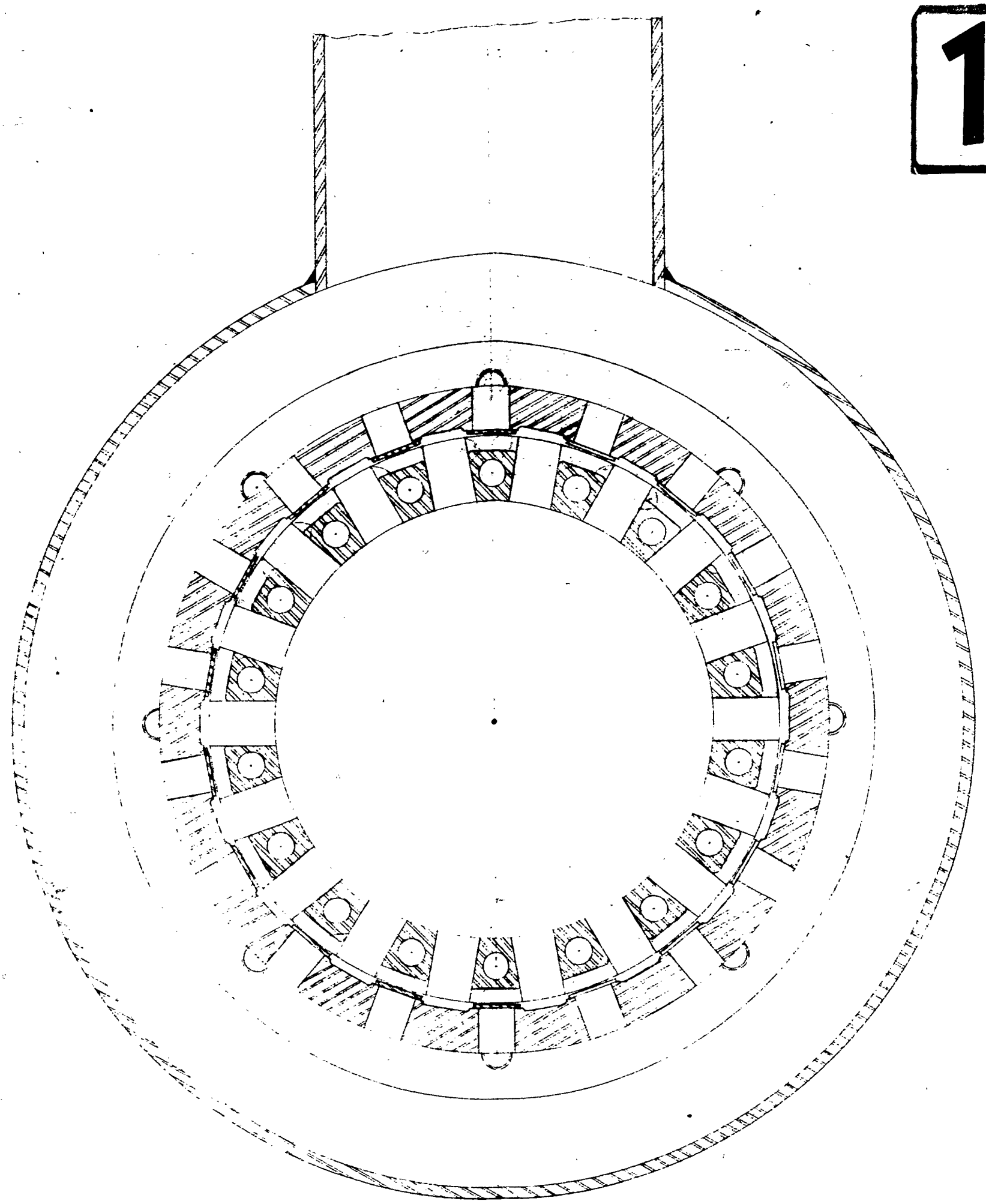
REPORT NO. [redacted]
CURVE NO. 6191





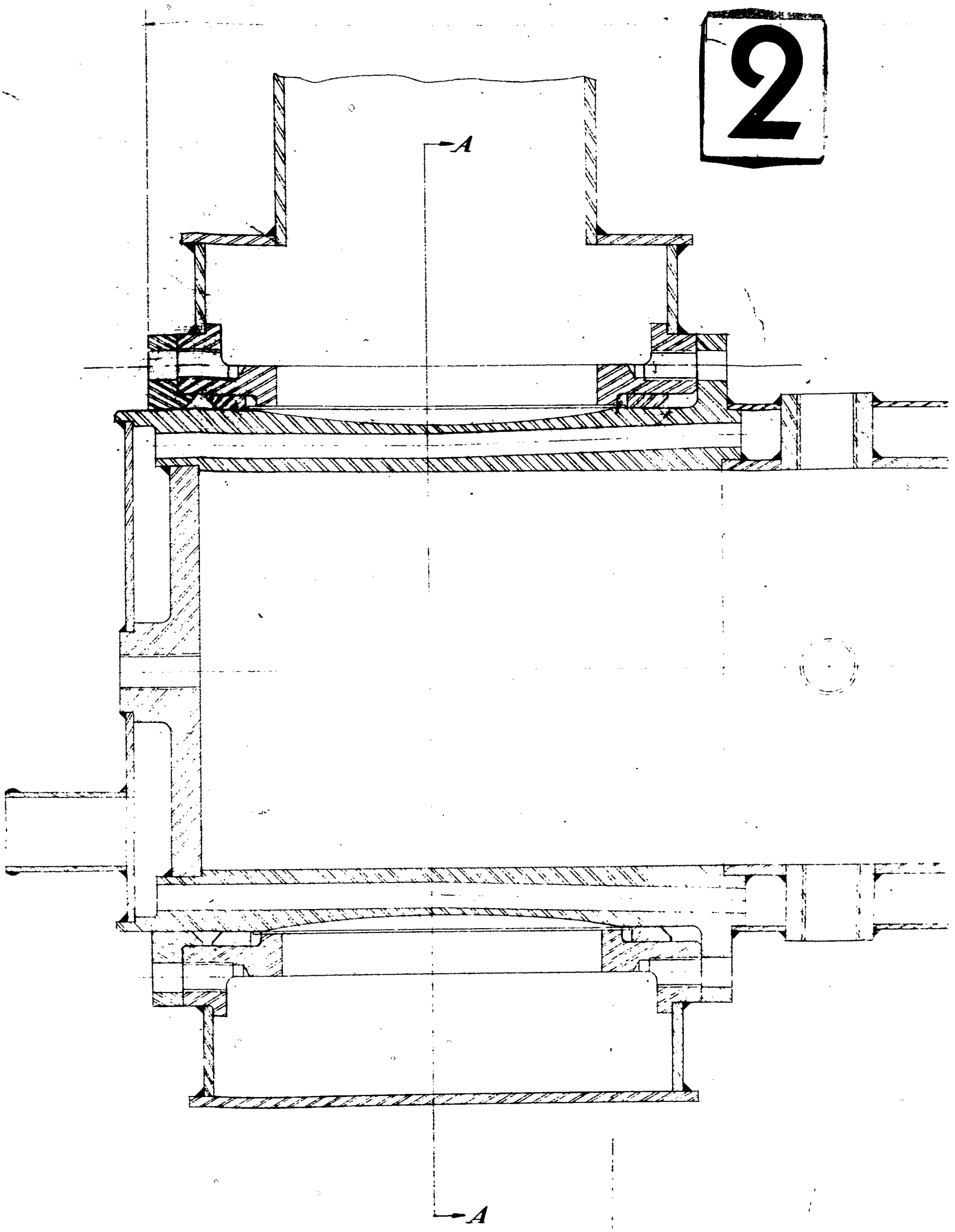
SECTION A-A

1



SECTION A-A

2



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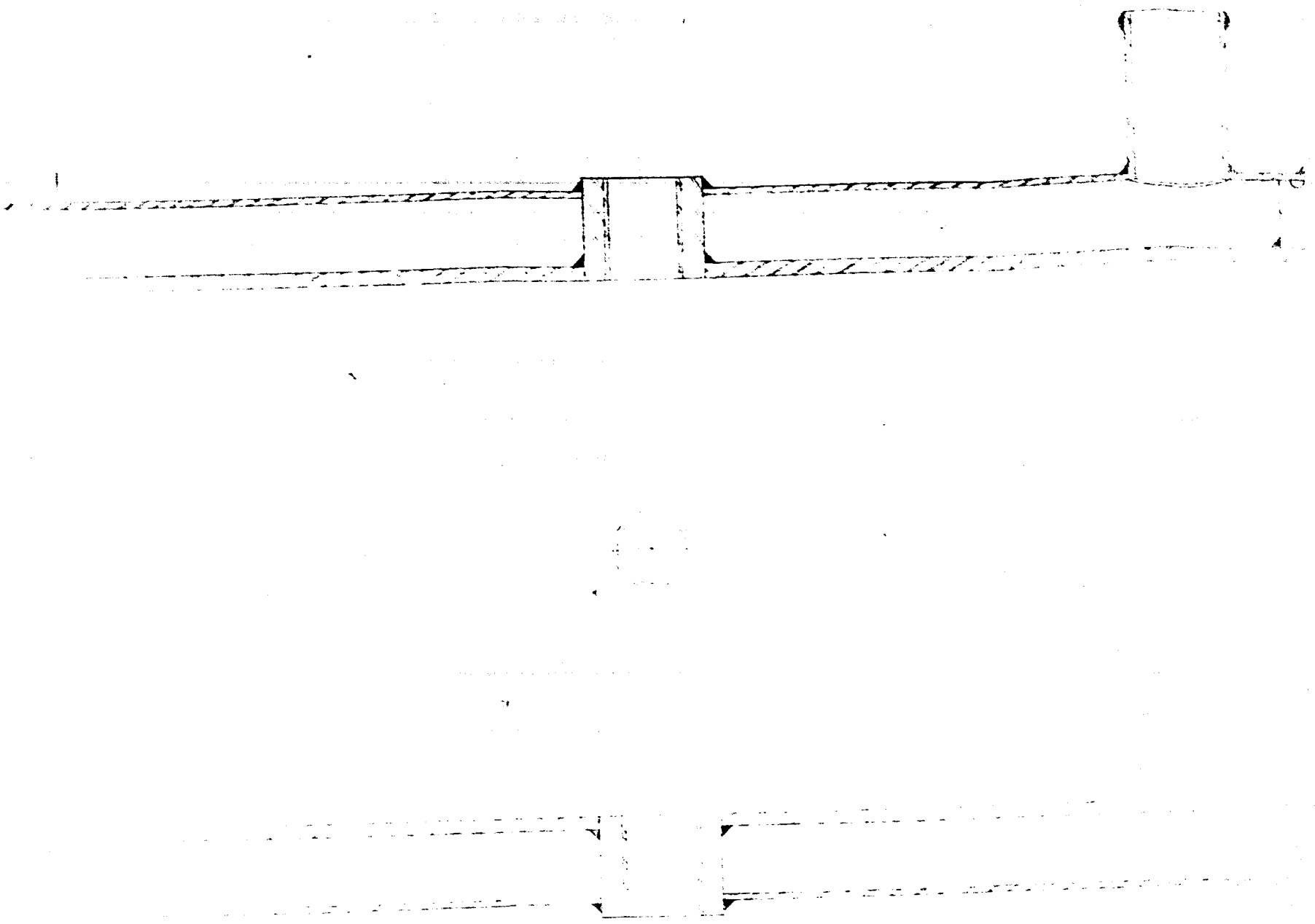

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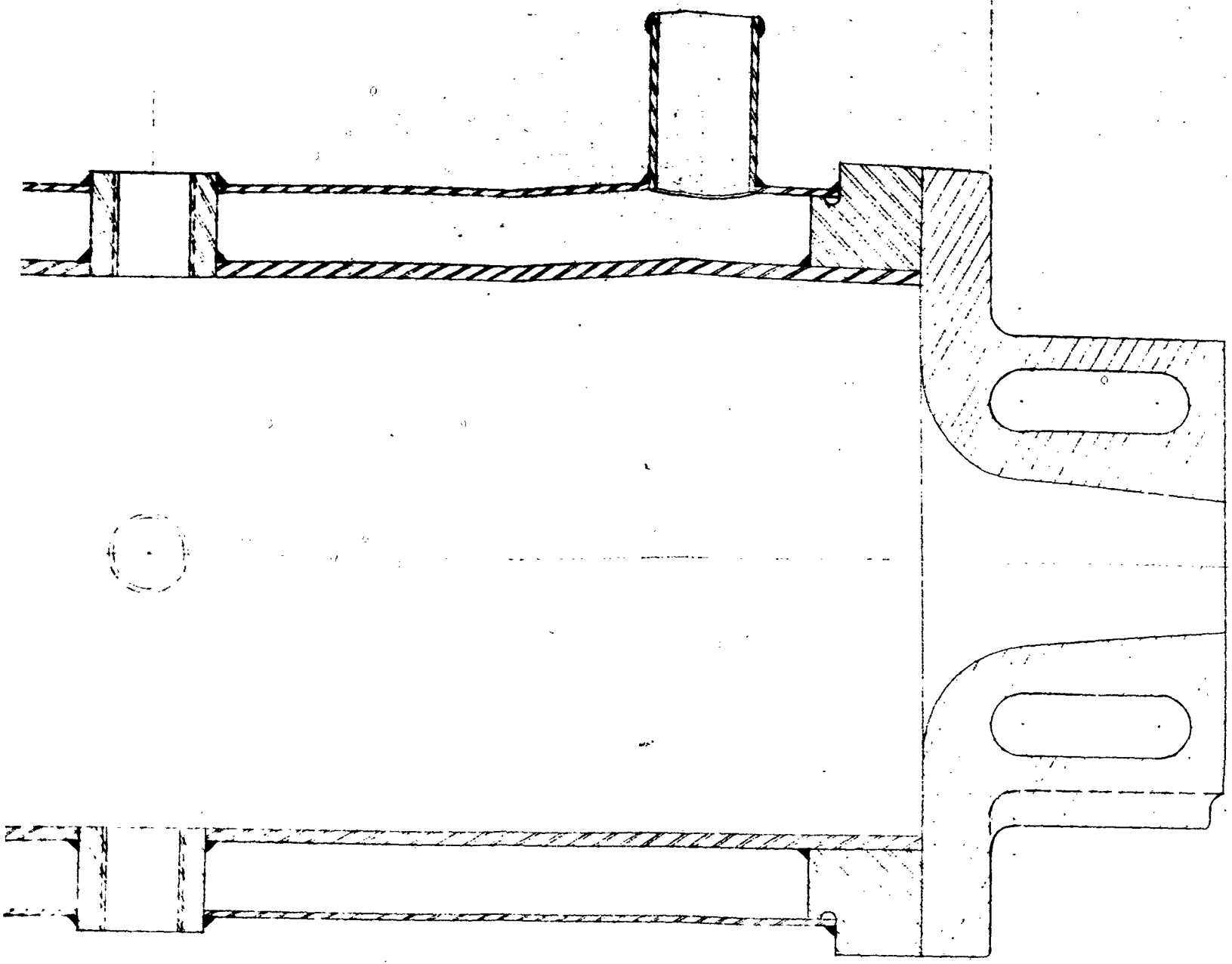

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COMBUSTION CHAMBER
REED VALVE - WATER COOLED